Section 7.1
Grassed Underdrained Soil Filter BMP
December 2012

7.1.1 Description

Vegetated underdrained soil filters control stormwater quality by capturing and retaining runoff and passing it through a filter bed comprised of a specific soil media. Soil filters having a mixture of silty sand and organic matter achieve the highest removal rates as they can remove a wide range of pollutants from stormwater, including suspended sediment, phosphorus, nitrogen, metals, hydrocarbons and some dissolved pollutants. Once through the soil media, the runoff is collected in a perforated underdrain pipe and discharged downstream. The filter structure provides for the slow release of smaller storm events, minimizing stream channel erosion, and cooling the discharge. Vegetated soil filters are usually located in close proximity to the origin of the stormwater runoff and should be scattered throughout a residential area or along the downhill edge of smaller parking areas.

Underdrained soil filters provide quantity control and channel protection as the underdrain releases the discharge of runoff, which protects streams from channel erosion associated with more frequent increased flow volumes. The slow discharge also cools the runoff, reducing thermal impacts to receiving streams. If flood control is required, detention within the structure or in parallel to must be provided.

Underdrained soil filter structures must detain a runoff volume equal to the sum of 1.0 inch times the subcatchment's impervious area plus 0.4 inch times the subcatchment's landscaped developed area. This surface area of a grass filter bed should represent no less than the sum of 5% of the impervious area and 2% of the landscaped area draining into it, with other upgradient areas directed away from the basin.

When used to meet the phosphorus allocation in lake watersheds, the sizing of the underdrain filter structures needs to be adjusted in accordance with Volume II of this BMP manual.

The peak storage depth of the channel protection volume within a grassed filter structure may not exceed 18 inches and should be designed to drain dry within 24 to 48 hours.

Storage and detention for flooding conditions and to meet the 2, 10 and 25-year peak flow control is allowed within the structure and over the channel protection volume provided that it will drain within 12 hours.

The underdrained soil filters must be planted with plant species that are tolerant of draught conditions with frequent inundation. Full vegetation must be achieved within the first year following construction.

7.1.2 Site Suitability Criteria

Drainage Area: The size of the underdrained soil filter and storage capacity over the filter is based on the size and land use within the area draining to the structure.

Depth to Groundwater: In most instances, the bottom of the underdrained soil filter should be above the seasonal high ground-water table.

Test Pits: One test pit shall be excavated in the area of the filter bed to identify the depth to groundwater and bedrock.

Bedrock: If bedrock is close to the surface an impermeable liner may be required to prevent rapid injection and contamination of the groundwater within fractures in the bedrock. If

the basin does not have one foot of soil overburden between bedrock and the bottom of the underdrain layer, the basin must be lined with an impermeable geomembrane (not with clay).

Permeable Soils: In soil group A and, in some cases, soil group B, an underdrained filter basin should be designed as an infiltration basin provided that the design and siting criteria from Appendix D of Chapter 500 (Stormwater Management Rules) can be met. Otherwise, a low permeability liner (not clay) must be used.

7.1.3 General Design Criteria

The following design criteria apply to all underdrained soil filters.

Treatment Volume: An underdrained soil filter must detain and filter a runoff volume equal to 1.0 inch times the subcatchment's impervious area plus 0.4 inch times the subcatchment's landscaped developed area. Other upgradient areas should be directed away from the filter basin.

Filter Area: The area of the filter (surface area of the filter) must be no less than the sum of 5% of the impervious area and 2% of the landscaped area draining to the filter.

Basin Size: The size of a filter bed should not exceed 3000 sq. ft in basin bottom area or have more than 2.5 acres of subwatershed draining to the structure. Larger sizes are difficult to construct and maintain.

Construction Components: Underdrained filters are constructed in excavated holes that are at least three feet deep and consist of, from bottom up:

- A geotextile fabric between natural soils and constructed media. An impermeable membrane may be required if groundwater contamination is a concern.
- A 12 to 14 inch base of coarse clean stone or coarse gravel in which a 4 to 6 inch perforated underdrain pipe system is bedded.
- A gravel transition layer, if necessary.
- 18-inch layers of uncompacted soil filter media.
- A surface cover of grass and mulch.
- Depression for surface stormwater storage

Impoundment Depth: The peak water quality storage depth may not exceed 18 inches over a grass filter that must drain dry in no less than 24 and no more than 48 hours. Storage over the treatment volume may be provided to control peak flows from the 2, 10 and 25 year storms and meet the flooding standards but must drain within 12 hours.

Outlet: The channel protection volume must be discharged solely through an underdrained vegetated soil filter bed with a network of underdrain pipe having a single outlet with a diameter no greater than eight inches. A manually adjustable valve may be installed to control the outflow rate from the underdrain pipe to obtain the required 24 to 48 hour release time.

Underdrain Outlet: Each underdrain system must discharge to an area capable of withstanding concentrated flows and saturated conditions without eroding.

Sediment Pretreatment: Pretreatment devices such as grassed swales, grass or meadow filter strips and sediment traps shall be provided to minimize the discharge of sediment to the underdrained soil filter. Pretreatment structures shall be sized to hold an annual sediment loading calculated using a sand application rate of 50 cubic feet per acre per year for sanding of roadways, parking areas and access drives within the subcatchment area.

Access: Where needed, a maintenance access shall be planned for and maintained that is at least 10 feet wide with a maximum slope of 15% and a maximum cross slope of 3%. This access should never cross the emergency spillway, unless the spillway has been designed for that purpose. An easement for long-term access may be needed.

7.1.3 Specific Design Criteria

Underdrain Pipe: Proper layout of the pipe underdrain system is necessary to effectively drain the entire filter area. There must be at least one line of underdrain pipe for every eight feet of filter area's width. The slope of the installed underdrain pipe must be positive. The underdrain piping should be 4" to 6" slotted, rigid schedule 40 PVC or SDR35. Structure joints shall be sealed so that they are watertight. Underdrain pipes must be placed no further than 15 feet apart.

Pipe Bedding and Transition Zone: The 4 to 6 inch diameter perforated underdrain pipe(s) must be bedded in 12 to 14 inches of underdrain material with at least 4 inches of material beneath the pipe and 4 inches above. Two options for pipe bedding are provided below; however Option 1 is preferred:

OPTION 1 - Drainage Layer: The underdrain material consists of well graded, clean, coarse gravel meeting the MEDOT specification 703.22 Underdrain Type B for Underdrain Backfill (see Table 7.1). The material must contain less than 5% fines passing the #200 sieve. No transition zone is necessary since the drainage pipe is bedded in less pervious gravel and this design is acceptable for areas where the head or depth to seasonal high groundwater is close to the bottom of the drainage layer.

OPTION 2 – Drainage Layer with Transition None: The underdrain bedding material must consist of 12 inches of crushed stone meeting the MEDOT specification 703.22 Underdrain Type C for Underdrain Backfill Material (see Table 7.1). As a transition zone, a 6 inch layer of well graded, clean, coarse gravel meeting the MEDOT specification 703.22 Underdrain Type B for Underdrain Backfill Material (see Table 7.1) is needed above the crushed stone bedding. The amount of fines passing the #200 sieve in the gravel should be preferably less than 5%.

Soil Filter Bed: The soil filter must be at least 18 inches deep on top of the gravel underdrain pipe bedding and must extend across the bottom of the entire filter area. This soil mixture shall be a uniform mix, free of stones, stumps, roots, or other similar objects larger than two inches. No other materials or substances that may be harmful to plant growth, or prove a hindrance to the planting or maintenance operations can be mixed within the filter.

Filter Bed: Two options are provided for the treatment portion of the basin.

OPTION 1- Soil Filter Media: Soil media must consist of a silty sand soil or soil mixture combined with 20% to 25% by volume (no less than 10% by dry weight) of a moderately fine shredded bark or wood fiber mulch.

TABLE 7.1 Maine DOT Specifications for Underdrains (MEDOT #703.22)

Sieve Size	**% by Weight**
UNDERDRAIN - TYPE B	
1”	90-100
½”	75-100
#4	50-100
#20	15-80
#50	0-15
#200	0-5
UNDERDRAIN - TYPE C	
1”	100
¾”	90-100
3/8”	0-75
#4	0-25
#10	0-5

Other organic sources must be approved by the department; however an agricultural source is not acceptable for the organic component of the media.

The resulting mixture must have no less than 8% passing the 200 sieve and shall have a clay content of less than 2%. The system must be designed to drain the surface storage volume in no less than 24 hours and no more than 48 hours.

TABLE 7.2 Maine DOT Specifications for Aggregate (MEDOT #703.01)	
Sieve Size	**% by Weight**
3/8”	100
#4	95-100
#8	80-100
#16	50-85
#30	25-60
#60	10-30
#100	2-10
#200	0-5

As an example, the mixture may contain by volume the following:

- *50% of sand (MEDOT #703.01 contains insufficient fine for the media)*
- *20% of loamy topsoil*
- *30 % of composted woody fibers and fine shredded bark, superhumus or equivalent(adjusted for mineral soil content)*

OPTION 2 – Layered System with Topsoil

Because of its coarseness, a filter media mixed from different sources may lack nutrients, may be unable to retain moisture, and maybe be devoid of micro-organisms (such as fungus, bacteria and nematodes) which are found in a natural soil and which benefit the germination and establishment of vegetation. Natural soils will contain these important organisms and provide superior filtration. Option 2 provides for a layered system that takes advantage of the characteristics of natural soils. The different layers from the bottom up are:

***Optional hay layer*:** A layer of hay can be placed to separate the drainage layer from the treatment layer above to prevent subsidence or plugging of the sand/gravel/stone layer and/or pipe.

Filter Layer: A 12 inches layer of loamy coarse sand which is loosely installed should meet the grain size specifications of Table 7.3.

Topsoil: The surface of the basin should be covered with 6 inches of non-clayey, loamy topsoil such as USDA sandy loam topsoil with 5-8% humified organic matter and meeting the specifications provided in Table 7.4. Topsoil from the development may be appropriate but should be tested for organic content and clay content (hydrometer test). The soil must be screened, loose, friable, and shall be free from admixtures of subsoil, refuse, stones (greater than 2 inches in diameter), clogs, root and other undesirable foreign matter. The topsoil should be gently mixed within the filter layer to provide continuity for deep root penetration. The teeth of a backhoe, a hand rake, a shovel or rototilling 2-3 inches may be used as a way to create a loosened transition.

TABLE 7.3 Specifications for Loamy Coarse Sand	
Sieve #	**% Passing by Weight**
10	85-100
20	70-100
60	15-40
200	8-15
200 clay size	<2.0

TABLE 7.4 Specifications for Sandy Loam to Fine Sandy Loam	
Sieve #	**% Passing by Weight**
4	75-95
10	60-90
40	35-85
200	20-70
200 clay size	< 2.0

Clay Content: Use of soils with more than 2 % clay content could cause failure of the system and care should be taken, especially in areas where the predominant soil contains marine clay, that the sand and topsoil used in the mixture have very little or no clay content.

Filter Permeability: The filter must be permeable enough to insure drainage within 48 hours maximum, yet have sufficient fines to insure filtration of fine particles and removal of dissolved pollutants. The design may either rely on the soil permeability, if known, to provide the slow release of the water treatment volume over a minimum of 24 hours, or may insure this rate by installing a constrictive orifice or valve on the underdrain outlet. In

determining the permeability of the media, the percent fines of the mixture and the level of compaction should be considered. Generally, the soil media should be only lightly compacted between 90 and 92% standard proctor (ASTM D698) and shall have a permeability of 2.4 in/hr to 4 in/hr.

Gradation testing: Gradation tests, including hydrometer testing for clay content, and permeability testing of the soil filter material, shall be performed by a qualified soil testing laboratory and submitted to the project engineer for review before placement and compaction.

Geotextile Fabric: A geotextile fabric with suitable characteristics may be placed between the sides of the filter layer and adjacent soil. The fabric will prevent the surrounding soil from migrating into and clogging the filter and clogging the outlet. Overlap seams must be a minimum of 12 inches. Do not wrap fabric over the top of the pipe bedding as it will cause clogging and will prevent flows out of the filter. The geotextile fabric shall be Mirafi 170n or equivalent.

Rock Forebay: A rock forebay is recommended to reduce flow velocity into the basin. It shall remain clear of sediment until the upgradient tributary area is fully vegetated

Vegetation: The soil filter surface must be planted with a grass species that is tolerant of frequent inundation and well drained soils. Upon seeding, the soil filter shall be mulched with hay or an erosion control blanket but must not be fertilized. An appropriate seed mixture should contain the following or be an approved equivalent conservation type mixture:

Creeping red fescue	20 lbs/acre
Tall fescue	20 lbs/acre
Birdsfoot trefoil	8 lbs/acre
Total	48 lbs/acre

7.1.4 Construction Criteria

Basin excavation: The area of the basin may be excavated in preparation of the installation of the underdrain and can be used for a sediment trap from the site during construction. After excavation of the basin, the outlet structure and piping system must be installed at the appropriate elevation and protected with a sediment barrier. If the basin is to be used as a sediment trap, the sides of the embankments must be mulched and maintained to prevent erosion.

Compaction of soil filter: Filter soil media and underdrain bedding material must be compacted to between 90 and 92% standard proctor. The bed should be installed in at least 2 lifts of 9 inches to prevent pockets of loose media.

Outlet Discharge Outflow of the filter basin underdrain can be controlled by a constrictive orifice or a valve (2" plastic ball valve, type 346, with a ball valve handle extension, type 615, with a three-piece valve box installed over the valve). Upon completion of the installation of the soil filter media and the establishment of 90% of grass cover over the filter media, the contractor shall flood the vegetated basin to the design elevation with clean water and adjust the outflow to obtain a 24 hour to 32 hour release time.

Construction Sequence: Erosion and sedimentation from unstable subcatchments is the most common reason for filter failure. Not heeding the construction sequencing criteria is likely to result in the need to replace the soil filter. The soil filter media and vegetation must not be installed until the area that drains to the filter has been permanently stabilized with pavement or other structure, 90% vegetation cover, or other permanent stabilization. Otherwise, the runoff from the contributing drainage area must be diverted around the filter until stabilization is completed unless the Department has determined, on a case-by-case basis, that sufficient measures are being taken to prevent erosion of material from the unstable catchment area and deposition on the filter.

Remedial Loam Cover: If vegetation is not established within the first year, the contractor may install a 2-3 inch layer of sandy loam topsoil (with less than 2% clay as tested via hydrometer test) on the surface of the grass filter and reseed/mulch.

Construction Oversight: Inspection of the filter basin shall be provided for each phase of construction by the design engineer with required reporting to the DEP. At a minimum, inspections will occur:

- After preliminary construction of the filter grades and once the underdrain pipes are installed but not backfilled;
- After the drainage layer is constructed and prior to the installation of the filter media;
- After the filter media has been installed and seeded;
- After one year to inspect health of the vegetation and make corrections; and
- All material used for the construction of the filter basin will be approved by the design engineer after tests by a certified laboratory show that they are passing DEP specifications.

Testing and Submittals: The contractor shall identify the location of the source of each component of the filter media. All results of field and laboratory testing shall be submitted to the project engineer for confirmation. The contractor shall:

- Submit samples of each type of material to be blended for the mixed filter media and samples of the underdrain bedding material. Samples must be a composite of three different locations (grabs) from the stockpile or pit face. Sample size required will be determined by the testing laboratory.
- Perform a sieve analysis conforming to ASTM C136 (Standard test method for sieve analysis of fine and coarse aggregates; 1996a) on each type of the sample material. The resulting soil filter media mixture MUST have 8% to 12% by weight passing the #200 sieve, a clay content of less than 2% (determined hydrometer grain size analysis) and have 10% dry weight of organic matter.
- Perform a permeability test on the soil filter media mixture conforming to ASTM D2434 with the mixture compacted to 90-92% of maximum dry density based on ASTM D698.

7.1.5 Maintenance Criteria

During the first year, the basin will be inspected semi-annually and following major storm events.
Debris and sediment buildup shall be removed from the forebay and basin as needed.
Mowing of a grassed basin can occur semi-annually to a height no less than 6 inches.
Any bare area or erosion rills shall be repaired with new filter media or sandy loam then seeded and mulched.
Maintaining good grass cover will minimize clogging with fine sediments and if ponding exceeds 48 hours, the top of the filter bed must be rototilled to reestablish the soil's filtration capacity.

Maintenance Agreement: A legal entity should be established with responsibility for inspecting and maintaining any underdrained filter. The legal agreement establishing the entity should list specific maintenance responsibilities (including timetables) and provide for the funding to cover long-term inspection and maintenance.

Soil Filter Inspection: The soil filter should be inspected after every major storm in the first year to be sure it is functioning properly. Thereafter, the filter should be inspected at least once every six months to ensure that it is draining within 48 hours following a one inch storm or greater. And that following a storms that fill the system to overflow, it drains in no less than 36 to 6o hours. If the system drains too fast, an orifice may need to be added on the underdrain outlet or, if already present, may need to be modified.

Soil Filter Replacement: The top several inches of the filter shall be replaced with fresh material when water ponds on the surface of the bed for more than 72 hours. The removed

sediments should be disposed of in an acceptable manner.

Sediment Removal: Sediment and plant debris should be removed from the pretreatment structure at least annually.

Mowing: If mowing is desired, only hand-held string trimmers or push-mowers are allowed on the filter (no tractor) and the grass bed should be mowed no more than 2 times per growing season to maintain grass heights of no less than 6 inches.

Fertilization: Fertilization of the underdrained filter area should be avoided unless absolutely necessary to establish vegetation.

Harvesting and Weeding: Harvesting and pruning of excessive growth will need to be done occasionally. Weeding to control unwanted or invasive plants may also be necessary. Add new mulch only as necessary for bioretention cell